U.S. Muon Accelerator Program Memorandum

From: Mark Palmer, MAP Director, Fermilab

To: Derun Li, MAP Laboratory Manager, LBNL
Soren Prestemon, Division Deputy, ATAP Division, LBNL

Subject: Engineering Design Review of MICE RF Module

April 21, 2015

Dear Derun and Soren,

This memorandum is to identify key issues for evaluation at the Engineering Design Review of the MICE RF Module to be held April 30-May 1, 2015. This review represents the final opportunity to obtain input on the MICE RF Module Engineering Design prior to entering the procurement phase for two units of this critical piece of hardware. A prior review focused on the vacuum system issues associated with obtaining a sufficiently good quality vacuum. We need to cover the two primary topics in detail to ensure that we are ready to proceed: the RF Module Engineering Design and the Vacuum System Requirements. In addition to these primary issues, we also want to set aside some time to discuss: 1) the assembly, preliminary testing and shipping plans; and 2) interface issues (including instrumentation requirements) to the RF control system being designed principally by Daresbury Laboratory and Strathclyde University. Thus we have asked Colin Whyte (Strathclyde) to provide a brief overview that will be the basis of further discussion.

The MICE 201 MHz RF module has several unique features:

- The RF cavity is a closed pillbox design where the beam traverses thin Be windows that cover the irises;
- The RF system is intended for operation in Tesla-class magnetic fields; and
- The RF cavity utilizes a clean electropolished surface to improve its breakdown performance.

The two primary topics to be addressed at the review are:

I. A review of the readiness of the RF Module Engineering Design for component fabrication and, where further prototyping work may be required, to define the timeline for completing the necessary steps. Items that should be explicitly addressed include:
    1. Readiness of vacuum vessel design for fabrication –
        a. Identify any remaining issues or questions with respect to the design;
        b. Evaluate the adequacy of the specified complement of ports presently specified for the vessel;

   c. Review the planned surface preparation specifications for the vessel;
   d. Review the acceptance requirements for the vessel.
2. Readiness of the RF cavity tuner actuators for fabrication –
   a. Summarize the status of and results from the prototype test program;
   b. Summarize any tests that are remaining;
   c. Identify any remaining design issues or issues that have arisen in the test program;
   d. Specify the procedures for dealing with actuator failures during operation.
3. Readiness of the RF coupler for fabrication –
   a. Summarize all recent vacuum and mechanical modifications and any test results that are available;
   b. Comment on the robustness of the present design for shipping.
4. Readiness of the cavity bodies and windows for RF module assembly –
   a. Summarize the results of the recent cavity selection and electropolishing process;
   b. Review the acceptance requirements for each cavity body;
   c. Summarize the results of the Be window selection process.

II. A review of the vacuum system requirements of the RF module when it is installed in the MICE Cooling Channel. Items that should be explicitly addressed include:
1. The expected conductance between the interior of each cavity and the cooling channel vacuum in the present engineering design/
2. The anticipated vacuum pressure attainable in the cavity given the pumping design, the connection to the cooling channel assuming a base pressure of $1\text{-}3\times10^{-6}$ Torr in the cooling channel (note that these numbers are slightly worse than the assumptions used in January) and using the observed MTA cavity gas pressure and composition.
3. The maximum differential pressure that can be sustained by the Be windows
   a. Specify the methods used to develop the differential pressure rating;
   b. Identify any tests or calculations that may be required before deployment of the module in order to confirm the ratings;
   c. Specify the vacuum system procedures and interlocks required to protect the Be windows.
4. The procedures required to:
   a. Evacuate the system safely while maintaining acceptable differential pressure across the Be windows;
   b. Bring the system back to atmosphere safely while maintaining acceptable differential pressure across the Be windows;
   c. Protect the system in case of a catastrophic failure to the external vacuum system in the MICE cooling channel;
   d. Protect the system in case of a catastrophic failure to the internal cavity vacuum system;

5. Identify any specification, operational, or interlocking requirements that may that may be required for the main MICE vacuum system in order to accommodate the RF module.

In addition, to the two primary issues for this review, we also propose to discuss the RF Module assembly process at LBNL. The key assumptions presently in our plan for this process are:

1. The modules and all components will arrive at LBNL early in FY16 and all acceptance checks and preliminary preparations will take place there;
2. Assembly of the two RF modules will take place at LBNL starting at the beginning of calendar 2016 and utilizing an enhanced clean room based on that available for RFQ work, but with greater filter coverage to improve the overall air quality;
3. The LBNL assembly and testing team will be augmented by members of the SCTS assembly team (FNAL and IIT members) to expedite the assembly process at LBNL;
4. A vacuum bakeout and subsequent low power RF tests will all be carried out before each RF module is shipped to RAL;
5. The RF Modules will ship to RAL as complete units (including Be windows and mounted RF couplers) under a dry N_2 atmosphere so that they can be mated directly to the RF systems in the MICE Hall for operational testing prior to being installed in the cooling channel;
6. The RF Modules will be shipped sequentially to RAL as they become ready.
7. The overall schedule aims for the final module to arrive in the UK by early June 2016.
8. A suitable set of inspection and acceptance procedures for the modules at RAL must be defined.

It will be important to discuss the validity of all of these assumptions at the review and to review the overall assembly schedule.

Finally, another secondary topic will be to review the RF interface specifications at RAL. An overview of the present status of the RF system plan by Colin Whyte will initiate this topic. We plan to initiate a more detailed review of these issues later in the summer.

Please let me know if there are items missing from this memo that you believe require explicit discussion at the review.

cc: Steve Virostek, LBNL
Alan Bross, FNAL